- **Alternative 3A** – A nominal 12-inch thickness of sand, overlain with 3 inches of appropriate gravel armor cover (see below).
- **Alternative 3B** – 6 to 12 inches of sand (gas venting layer), overlain with a nominal 6 inches of AquaBlok™, and covered with an additional 3 inches of gravel armor (gravel is also incorporated into the AquaBlok™ product).
- **Alternative 3C** – 6 to 12 inches of sand (gas venting layer), overlain with a nominal 18 inches of AquaBlok™, and covered with an additional 3 inches of gravel armor.
- **Alternative 3D** – A nominal 6-inch thickness of granular bituminous coal, overlain with 6 inches of sand, and covered with an additional 3 inches of gravel armor. The nominal thickness of the coal layer in Alternative 3D was based on the results of chemical transport modeling and safety factor considerations, as discussed in more detail in Section 6.2.3.
- **Alternative 3E** – A nominal 18-inch thickness of granular bituminous coal, overlain with 6 inches of sand, and covered with an additional 3 inches of gravel armor.

Figure 4 shows generalized cross sections of Alternatives 3A through 3E. As discussed under Alternatives 1 and 2, upstream source controls for PCBs, as necessary, would be implemented under existing wastewater discharge permits and future TMDL allocation-based limits.

The reactive materials included in the above alternatives, including higher organic carbon components of AquaBlok™ and granular bituminous coal, provide for greater adsorption of chemicals such as PCBs from sediment porewater prior to diffusion into overlying cap layers, further improving the long-term effectiveness and permanence of the remedy (McShea et al. 2002, McLeod et al. 2004, Reible and Constant 2004). The effectiveness of capping would be verified through long-term monitoring, though fewer sampling events are anticipated to document the effectiveness of this option, compared with Alternative 2.

As discussed in Palermo et al. (1998a and 1998b), the surface of the cap would be designed to be thick enough and of sufficient grain size to maintain its integrity under reasonable worst-case environmental and human use conditions (e.g., to resist shear stresses under a 100-year flood condition). In order to ensure sufficient thickness to prevent significant scour under this flood condition, the armor layer would likely consist of a nominal 3 inches of material with a mean grain size of 1 inch, with a likely gradation specification of 50 percent of the material ranging between 1 and 4 inches, the other 50 percent passing 1 inch, and no more than 5 percent passing a number 200 sieve. This preliminary armor specification was based on initial, conservative stress calculations under a 100 year flow event for the Spokane River of 53,900 cfs (see Figure 5), normal pool elevation, and analysis of shear stresses at various locations within and adjacent to Deposit 1 (Appendix A). As part of final design, a more detailed hydrodynamic analysis may be completed using a more refined modeling analysis (e.g., 2-D SEDZL or HEC-RAS), that could more specifically address the effects of river meander and dam configuration/operation characteristics on hydrodynamics and bottom shear stresses at the Site. The design-level hydrodynamic model would be used to refine conservative shear stress estimates used in this Focused FS (Appendix A), and would likely conclude that a smaller armor grain size would suitably resist erosion potentially associated with peak flow events.

As discussed above, gravel components of the standard AquaBlok™ formulation as well as the cohesive strength of the clay fraction appear to be sufficient to resist the design erosive forces due to the presence of engrained gravels and the cohesive nature of the AquaBlok™ material. As generally described by the Hjulstrom diagram (see Appendix A), both the gravel and bentonite/clay components included as part of standard AquaBlok™ formulations have the capacity to resist erosion during peak flood flows at the Upriver Dam PCB Site. Nevertheless, in order to ensure the long-term integrity of the AquaBlok™ alternatives, an additional nominal 3-inch layer of gravel armor was included as the final cover, similar to the other capping alternatives (Figure 4). Again, more detailed hydrodynamic analyses would be performed during remedial design to develop final cap and armor specifications.

Based on various field trials and full-scale applications (Kate and Racine 1996, Hull et al. 1999, McShea et al. 2002, Reible and Constant 2004), AquaBlok™ is best placed mechanically. Similarly, cap armor material would be too coarse to place hydraulically with typically-available pump sizes. As with the thin-layer cap, all proposed alternatives for the cap sections at Deposit 2 would likely be placed mechanically from shore.

The sand and granular bituminous coal material could be placed using either the mechanical or hydraulic means described above for the thin layer cap (Section 5.2). The granular bituminous coal material may need to be saturated before placement to ensure even and effective coverage. The unit dry weight of the coal material is roughly 1 ton/CY. If the material were placed hydraulically, the contractor would likely use a submerged diffuser to place the material. The pipeline would have a 90 degree turn at the water surface and extend down to within 5 feet of the sediment surface. A horizontal plate would be located perpendicular to the slurry flow to dissipate the energy of the coal slurry. After dissipation, the material would settle to the bottom.

Many different regional and national sources exist for granular bituminous coal. Depending on the specific source, there could be potential concerns associated with accessory hazardous substances present in the coal, such as certain metals (e.g., mercury) and polynuclear aromatic hydrocarbons. However, there are also available sources of these materials that contain relatively low concentrations of accessory chemicals at or below existing freshwater AET and SQV guidelines (Michelsen 2003). If a coal or equivalent amendment to the cap system were selected as part of the final cleanup remedy, detailed specifications for acceptable material quality (e.g., chemical concentrations at or below minimum cleanup level criteria and with elutriate testing data demonstrating low leachability) would be developed during remedial design to ensure the protectiveness of the remedial action. Placement of a nominal 6-inch thickness of sand on top of the coal, along with the overlying gravel armor layer, would also ensure isolation of coal-associated chemicals from the biologically active layer (Figure 4).

The sections below summarize estimated tonnage requirements and estimated construction duration for each capping alternative applied to Deposits 1 and 2. Tonnage estimates assume typical overplacement allowances to address normal precision tolerances. The following cap material tonnages were estimated based on typical unit weights for placed materials in the region: 1.6 tons/CY for gravel, 1.5 tons/CY for sand, and 1.0 tons/CY for coal. Because of the relatively small size of Deposit 2, and since the relative performance of the different capping process options are already addressed for Deposit 1, only a single representative capping option (Alternative 3A; 12-inch nominal thickness of sand) was carried forward for Deposit 2. Due to its sheltered location behind Donkey Island, Deposit 2 would also likely not require armor protection, so no such gravel cover was included in the capping option developed for this area. Design and construction of all of the capping process options described herein could be completed within 1 to 2 years of execution of a Consent Decree.

5.3.3 Alternative 3A—12 Inches of Sand with Armor

At Deposit 1 approximately 11,000 tons of sand material would be placed under 5,000 tons of gravel armor material. This work would take 6 to 8 weeks to complete.

At Deposit 2 approximately 500 tons of sand material would be placed. An armor layer is likely not needed in Deposit 2. This work would take 2 to 3 weeks to complete.

5.3.4 Alternative 3B—6 Inches of AquaBlok™ with Armor

At Deposit 1 approximately 9,000 tons of sand would be placed as a gas venting layer (if required), overlain with 800 tons of AquaBlok™ material, and 5,000 tons of gravel armor. This work would take 5 to 8 weeks to complete.

5.3.5 Alternative 3C—18 Inches of AquaBlok™ with Armor

At Deposit 1 approximately 9,000 tons of sand would be placed as a gas venting layer (if needed), overlain with 2,400 tons of AquaBlok™ material, and 5,000 tons of gravel armor. This work would take 6 to 9 weeks to complete.

5.3.6 Alternative 3D—6 Inches of Coal and 6 Inches of Sand with Armor

At Deposit 1 approximately 4,000 tons of granular bituminous coal material would be placed under 7,000 tons of sand material, overlain with 5,000 tons of gravel armor. This work would take 8 to 10 weeks to complete.

5.3.7 Alternative 3E—18 Inches of Coal and 6 Inches of Sand with Armor

At Deposit 1 approximately 10,000 tons of granular bituminous coal material would be placed under 7,000 tons of sand material, overlain with 5,000 tons of gravel armor. This work would take 14 to 16 weeks to complete.

5.4 Alternative 4: Dredging, Off-Site Disposal, and Residuals Capping

Under this option, the top 3.5 feet (70 cm to bottom of impacted sediment; Figure 2; plus overdredge allowance) of sediments at Deposit 1 and the top 2 feet (30 cm to bottom of impacted sediment; plus overdredge allowance) at Deposit 2 that exceed the potential SQV (e.g., 60 μg/kg dw) would be dredged or excavated as practicable (i.e., excluding potentially problematic cobble/boulder areas), removing roughly 95 percent of the sediment PCB mass from the system and relocating it to a disposal site. A relatively small mechanical clamshell would be used to remove approximately 23,000 CY of in-place sediments and associated debris from Deposit 1, and the materials dewatered as necessary in a temporary shoreline dewatering facility located near the dredge area. Water from the dewatering process may require treatment to remove PCB particles prior to discharge.

While several different dredging technologies are available that can accomplish submerged sediment removal, mechanical dredges appear best suited to conditions in Deposit 1. The dredging system contemplated under Alternative 4 would consist of a barge-mounted excavator equipped with a hydraulically operated watertight bucket. Deposit 1 sediments, along with associated debris dredged with this equipment would likely be placed into a barge for transport to a shoreline offloading/rehandling/decanting facility. Based on site characteristics and experiences at other similar dredging projects, anticipated production rate for Deposit 1 dredging would be roughly 500 CY/day, requiring approximately 10 to 15 weeks of construction.

Dredged sediments, including residual water, are currently acceptable for landfill disposal at regional facilities (e.g., Roosevelt Regional Landfill). Cost estimates developed for this FS assumed that residual water generated during mechanical dredging operations would be transported to the landfill along with the dredged sediment.

Given the presence of woody debris, cobble, boulders, and other potential obstructions within Deposit 1 that will likely impede dredge efficiency and contribute to the development of residuals, a relatively thin layer of sediment residuals is anticipated to result from the dredging process, irrespective of the number of dredge passes performed. Thus, sediment residual remaining on the post-dredge surface, particularly in the relatively deep-water Deposit 1, would be allowed to remain in place, and would be contained below a nominal 2-foot-thick backfill/sand cap layer to prevent exposure to the biologically active zone or water column. The 2-foot-thick backfill would also restore existing grades in the area, minimizing habitat disturbances. Figure 4 illustrates Alternative 4.

For the purpose of this Focused FS, the Deposit 2 excavation area was assumed to be isolated during construction from the Spokane River by placement of a small sand dam to control water quality releases associated with excavation within this area. Under Alternative 4, approximately 700 CY of sediment would be removed from Deposit 2, requiring 1 to 3 weeks of construction.

Excavation of sediment in Deposit 2 could also be cost-effectively integrated into a larger habitat restoration action in the Donkey Island area. However, since habitat restoration actions (over and above construction mitigation requirements) are not required as part of a cleanup action mandated under MTCA, evaluation of such integrated actions was not addressed in this Focused FS.

The effectiveness of the dredge and cap remedy would be verified through water and sediment quality monitoring. Under this alternative, all dredge material (including residual water) was assumed to be hauled by rail to the Roosevelt Regional Landfill. As discussed under Alternatives 1 through 3 above, it is assumed that upstream source controls for PCBs, as necessary, would be implemented under existing wastewater discharge permits and future TMDL allocation-based limits.

Owing to the more complex nature of the Alternative 4 action, design and construction of Alternative 4 applied to Deposit 1 would likely require 2 to 4 years following execution of a Consent Decree. By comparison, design, permitting, and construction of Alternative 4 applied to Deposits 2 would likely be fully completed within a period of 1 to 2 years.

6 EVALUATION OF REMEDIAL ALTERNATIVES

This section provides a comparative evaluation of the four remedial alternatives (and sub-alternatives) described in Section 5, to support selection of a preferred cleanup action in accordance with MTCA requirements. MTCA identifies specific criteria against which alternatives are to be evaluated, and categorizes them as either "threshold" or "other" criteria. All cleanup actions must meet the requirements of the threshold criteria. The other MTCA criteria are considered when selecting from among the alternatives that fulfill the threshold requirements. The remedial alternatives are evaluated against the threshold criteria in Section 6.1, and against the other MTCA criteria in Section 6.2.

Although this section is organized to specifically address MTCA evaluation criteria, cleanup action requirements under other ARARs (as summarized in Section 3) are also incorporated into the discussion as appropriate. For example, the guidelines in 40 CFR 230.10(c) regulating discharges to waters of the United States were considered in evaluations of short-term risks (e.g., potential for contaminant releases during construction) and the effectiveness over the long term (e.g., potential for long-term discharges to surface water).

6.1 Threshold Criteria

The threshold MTCA requirements for a selected cleanup action are as follows:

- Protect Human Health and the Environment
- Comply with Cleanup Standards and Applicable State and Federal Laws
- Provide for Compliance Monitoring

The assessment against these criteria evaluates how the alternative complies with applicable risk-based cleanup standards and other applicable laws, including compliance with water quality protection components. This assessment also considers potential MTCA and SMS freshwater sediment cleanup standards.

All of the alternatives described in Section 5, including Alternative 1 – Monitored Natural Recovery, would be predicted with varying degrees of uncertainty to result in compliance with even the most stringent potential PCB cleanup standards and applicable laws, though the different alternatives would achieve this condition under varying time frames (see

Restoration Time Frame Section 6.2.1 below). All of the alternatives also provide for compliance monitoring.

6.2 Other MTCA Criteria

In this section, the remedial alternatives are comparatively evaluated against the following MTCA criteria:

- Provision for a reasonable restoration time frame
- Permanence
- Effectiveness over the long term
- Management of short-term risks
- Technical and administrative implementability
- Consideration of public concerns
- Cost

6.2.1 Provision for a Reasonable Restoration Time Frame

As defined in MTCA (Chapter 173-340-360[6]), this criterion evaluates when cleanup levels will be met at the point of compliance and potential risks alleviated. The practicability of achieving a shorter time frame is also assessed with this criterion.

The alternatives associated with the shorter restoration time frame and time required to implement and complete construction are Alternative 2 – Enhanced Natural Recovery (Thin Sand Cap) and all of the Alternative 3 Capping options (3A to 3E), which can be completed within 1 to 2 years of execution of a Consent Decree.

Alternative 4 – Dredging, Off-Site Disposal, and Residuals Capping could be implemented in an intermediate time frame, likely requiring 2 to 4 years following execution of a Consent Decree.

Finally, Alternative 1 – Monitored Natural Recovery, is associated with the longest restoration time frame in terms of achieving cleanup requirements, as the lowest potential cleanup standards may not be met for a period of 5 to 40 years (Figure 6), depending on sediment rates during the recovery period, and the final cleanup level selected by Ecology for the Site.

6.2.2 Permanence

As defined in MTCA (Chapter 173-340-360[5]), a permanent solution is one in which the cleanup standards can be met without further action being required at any site involved with the cleanup action. MTCA ranks the following types of cleanup action components in descending order of relative permanence:

- Reuse and recycling (and waste minimization under SMS)
- Destruction or detoxification
- Immobilization or solidification
- On-site or off-site disposal in an engineered, lined, and monitored facility
- On-site isolation or containment with attendant engineering controls
- Institutional controls and monitoring

Evaluations of remedial alternatives under MTCA to determine whether a cleanup option uses permanent solutions to the maximum extent practicable are discussed in WAC 173-340-360(3)(f)(ii), and focus on: "The degree to which the alternative permanently reduces the toxicity, mobility or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment process, and the characteristics and quantity of treatment residuals generated." Sequestration of PCBs as provided by reactive (organic) cap amendments are intended to enhance sorption onto the reactive media and irreversibly reduce hazardous substance mobility into surface sediment porewater and surface water under current ambient conditions, and in this capacity results in a higher permanence score under MTCA than caps without amendments. However, the degree of mobility control is dependent on the amount of sequestration provided, such as the TOC content incorporated into the cap design.

Thus, among the remedial alternatives evaluated in this FS, Kaiser and Avista interpret the MTCA preference for permanent solutions should rank Alternatives 3D and 3E, which achieve at least partial chemical immobilization due to organic sequestration with organics (e.g., see McLeod et al. 2004), the highest and Alternative 4 – Dredging, Off-Site Disposal, and Residuals Cap, which includes confinement at an engineered containment facility, the second highest. Alternative 4 provides off-site disposal in an engineered, lined, and monitored facility. As defined by the MTCA regulation, Alternative 4 is more permanent than on-site containment/capping, but less permanent than chemical immobilization. Since both immobilization and containment technologies have been integrated into Alternatives 3D and 3E, these alternatives were ranked as similarly permanent with respect to this MTCA evaluation criterion. Depending on the final TOC content of the AquaBlok™ cap design, Alternatives 3B and 3C may also provide a similar degree of permanence.

Alternative 2 – Enhanced Natural Recovery (Thin Sand Cap) and the Alternative 3A sand cap/armor option, are ranked intermediate on the MTCA preference scale, since such technologies rely solely on in situ isolation/containment.

Finally, Alternative 1 – Monitored Natural Recovery, which relies on natural sedimentation processes and monitoring to isolate contaminants, is associated with the lowest MTCA permanence score.

6.2.3 Effectiveness Over the Long Term

Long term effectiveness includes the degree of certainty that the alternative will be successful, the reliability of the alternative during the restoration time frame, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage remaining hazardous substances.

Part of the long term effectiveness evaluation, specifically as it is applied to the in situ capping and immobilization alternatives (Alternatives 2 and 3), was based on the results of one-dimensional chemical transport modeling performed for each alternative. The model presented in Reible (1998) was used, which is an appendix to current EPA and Corps Guidance for Subaqueous Dredged Material Capping (Palermo et al. 1998a and 1998b).

Specifically, the model described by Equation B32 of Reible (1998) was executed in Microsoft Excel to inform evaluations of long-term effectiveness of the various remedial alternatives. This model describes advective/diffusive transport of a dissolved chemical through a homogeneous porous media, such as an amended cap. The output of the model is expressed as the concentration of the chemical of concern (PCBs) in porewater at a specified time and depth within the cap. The model assumes no biodegradation of the chemical takes place over time. For this Focused FS assessment, the maximum porewater concentration of PCBs was calculated at the top of the cap isolation layer (i.e., 10 cm below the bottom of the armor layer, ignoring the additional containment benefit provided by the nominal 3-inch [8 cm] gravel armor) up to 500 years following construction. The model output thus also provides a relative assessment of surface water flux controls provided by the various alternatives, which in turn provides a measure of the magnitude of residual risk remaining under each alternative.

Table 1 presents the input parameters required by the model and the input values used for each alternative. Because the Reible (1998) model assumes a homogeneous sediment layer, it is not possible with the existing Corps/EPA guidance (Palermo et al. 1998a and 1998b) to directly model combined layers like those in Alternatives 3B to 3E. However, the layer that would most effectively retard chemical migration was modeled, and these results can be used as a conservative estimate of the overall effectiveness of combined layer alternatives. For Alternatives 3B to 3E, this "controlling" layer is either the AquaBlok™ or the coal layer, both of which more effectively control PCB migration due to their lower porosity and higher organic carbon content. Neglecting the additional attenuation properties of any upper sand and/or armor layer included with the alternatives provides a conservative FS-level estimate of the overall effectiveness of these cap alternatives.

Upward advection of groundwater through a cap can accelerate the rate of chemical migration and flux into surface water. However, these reaches of the Spokane River are known to have net exfiltration of river water to groundwater (Patmont et al. 1985, Anchor and Hart Crowser 2003). Therefore, the overall groundwater advection is assumed to be downward for this site, retarding the overall rate of chemical migration. However, for this modeling it was conservatively assumed that there is no net groundwater advection.

The concentration of PCBs in porewater in sediments to be remediated was estimated from the bulk sediment chemistry in subsurface cores. The porewater concentrations were calculated using standard PCB organic carbon partitioning coefficients (Table 1) and the measured TOC content of the sediments. Under existing conditions, the maximum calculated porewater concentration for any sample at any depth was approximately 600,000 pg/L of PCBs, which was from a sample collected 15 to 20 cm below the existing mudline (Core SC-2; Exponent and Anchor 2001; Figure 3). This maximum value for underlying sediment porewater concentration was used in all modeling runs, again to provide a conservative estimate of the long-term effectiveness of the remedial alternatives.

All other model input parameter values were obtained from standard sources noted in Table 1 including values for: cap porosity, specific gravity of cap material, cap material organic carbon content, partition coefficients for PCBs, and molecular diffusion coefficients for PCBs in water.

In addition to supporting the evaluation of long-term effectiveness, the transport model described above was also used in this Focused FS to determine the thickness of coal required to ensure the long-term effectiveness of Alternative 3D. The model was applied to potential placed coal thicknesses ranging from 0.5 to 6 inches, which equates to organic carbon loading of the cap isolation layer ranging from 7 to 85 kilograms organic carbon per square meter (kg OC/m^2), assuming a high degree of surface area and reactive efficiency from the coal (see Table 1 on grain size assumptions).

Results of the Alternative 3D cap effectiveness modeling are presented in Table 2. With the exception of the thinnest coal layer modeled (0.5-inch thick; 7 kg OC/m^2), the maximum predicted porewater concentrations at the top of the isolation layer were well below the EPA (2002) recommended surface water criterion of 64 pg/L for all Alternative 3D options that incorporated at least a .75-inch thickness of coal (greater than approximately 10 kg OC/m^2; defined by the approximate midpoint between the first two modeling runs summarized in Table 2).

Table 1
Summary of Cap Modeling Input Parameters

Parameter	Units	Alternative							Information Source
		2	3A	3B	3C	3D	3E	4	
Controlling Cap Layer	NA	Sand	Sand	AquaBlok	AquaBlok	Carbon[1]	Carbon[1]	Sand	FS alternatives
Cap Isolation Layer - Minimum Thickness	cm	5	30	15	46	8	46	61	Alt 3a: Assumed effective thickness was 91 cm less 10 cm at cap surface for bioturbation. Alts. 3b-3e: Assumed minimum thickness of controlling layer, which is overlain by a gravel armor layer in each case.
Cap Grain Size	microns	100 - 500	100 - 500	1 - 10	1 - 10	100 - 500	100 - 500	100 - 500	Typical values for placed sand, AquaBlok, and coal.
Cap Material Porosity	unitless	0.4	0.4	0.3	0.3	0.4	0.4	0.4	Typical values for placed sand (either mineral or carbon) and AquaBlok after hydration.
Specific Gravity of Cap	g/cm^3	2.6	2.6	1.9	1.9	1.1	1.1	2.6	Typical values for these materials (bitumious coal assumed for 3d and 3e).
In situ Bulk Density Cap	g/cm^3	1.6	1.6	1.3	1.3	0.7	0.7	1.6	Calculated from porosity and specific gravity per page B24 of Reible (1998).
Cap TOC Content	fraction	0.001	0.001	0.005	0.005	0.80	0.80	0.001	Typical values for these materials.
PCB K_{oc}	L/kgOC	820,000	820,000	820,000	820,000	820,000	820,000	820,000	MTCA Table 747-I.
PCB Cap K_d	L/kg	820	820	4,100	4,100	656,000	656,000	820	$K_d = K_{oc}$ * TOC.
Groundwater Upward Seepage Velocity	cm/yr	0	0	0	0	0	0	0	Groundwater advection downward due to exfiltration. Conservatively assumed zero velocity.
PCB Diffusion Coefficient	cm^2/yr	190	190	190	190	190	190	190	Conservatively high value from range of diffusion coefficients for PCBs (Reible 1998).
PCB Porewater Concentration in Underlying Sediments	pg/L	600,000	600,000	600,000	600,000	600,000	600,000	40,000	Maximum porewater concentration calculated from bulk PCB chemistry from subsurface cores (see Figure 3).

Notes:

1 - Granular bituminous coal

Koc - Organic Carbon Partitioning Coefficient

Kd - Calculated partitioning equilibrium coefficient

TOC - Total Organic Carbon

Table 2
Summary of Modeling Results for Alternative 3D Cap Options

Alternative 3D Cap Option	Cap Isolation Layer Carbon Loading (kg OC/m^2)	Maximum Future (500 Yr) Porewater PCB Concentration 10 cm Below Mudline (pg/L)
.5 inch Coal and 6 inches Sand	7	240
1 inch Coal and 6 inches Sand	14	< 0.000001
2 inches Coal and 6 inches Sand	28	< 0.000001
3 inches Coal and 6 inches Sand	43	< 0.000001
4 inches Coal and 6 inches Sand	57	< 0.000001
5 inches Coal and 6 inches Sand	71	< 0.000001
6 inches Coal and 6 inches Sand	85	< 0.000001

Based on the modeling described above, long-term effectiveness of Alternative 3D could be achieved by specifying a minimum coal thickness of .75-inch, and/or a minimum organic carbon loading of the cap isolation layer of 10 kg OC/m^2. Considering the range of cap material placement accuracies and monitoring methods used successfully in other similar applications (e.g., see http://www.hsrc-ssw.org/pdf/RB28.pdf), and incorporating additional safety factors into the conceptual design to ensure its permanence, this performance specification could be achieved using one of three possible Alternative 3D design options:

- **Alternative 3D-1** – Precision hydraulic or mechanical placement of approximately 6 to 8 inches of coal, verified in the field with detailed construction monitoring observations (e.g., sediment profile imaging [SPI] on a nominal 50-foot grid pattern), to ensure that a minimum 4 inches of coal material is placed at all SPI stations. The coal layer placed in this manner would provide a minimum factor of safety of 4 to the overall cap design (see above). The coal layer would then be overlain with a minimum 6 inches of sand, and covered with a minimum 3 inches of gravel armor.
- **Alternative 3D-2** – Standard mechanical or hydraulic placement of 6 to 9 inches of coal, verified in the field with more conventional construction monitoring observations (e.g., bathymetric surveys on 25-foot transects, along with diver-monitored stakes), to ensure that a minimum 4 inches of coal material is placed along all bathymetric transects. The coal layer would then be overlain with a minimum 6 inches of sand, and covered with a minimum 3 inches of gravel armor.

- **Alternative 3D-3** – Onshore/upland mixing of coal and sand materials to achieve a minimum blended TOC content of approximately 20 percent. Placement of 9 to 12 inches of the blended coal/sand mixture would be performed using standard mechanical or hydraulic methods, verified in the field with conventional construction monitoring observations (e.g., bathymetric surveys on 25-foot transects), to ensure that a minimum 6 inches of the blended coal/sand mixture is placed along all bathymetric transects. The blended coal/sand layer applied in this manner would ensure organic carbon loading of at least 40 kg OC/m^2, providing a minimum factor of safety of 4 to the overall cap design (see above). The coal/sand layer would then be covered with a minimum 6 inches of clean sand and capped with a minimum 3 inches of gravel armor.

All three of the options outlined above are considered protective and implementable. Selection of specific process options will be made in the CAP or engineering design phase after more detailed cost analyses are completed. Since preliminary FS-level analyses suggest that the most cost-effective option in this application is likely to be Option 3D-1, as described above, this representative process option has been carried forward as Alternative 3D in this Focused FS document (e.g., forming the basis for cost estimates of this alternative as discussed below).

Results of long-term effectiveness modeling are presented in Table 3 in terms of the maximum subsurface sediment porewater PCB concentration at the top of the cap isolation layer (10 cm below mudline), up to 500 years following construction. Significantly, the maximum porewater concentration below the top of the isolation layer for all engineered cap alternatives (i.e., Alternates 3A to 3E and 4) was below EPA's (2002) recommended surface water criterion of 64 pg/L, suggesting that all such alternatives are associated with a high degree of long term effectiveness. Placement of additional thicknesses of AquaBlok™ or coal materials, as provided in Alternatives 3C and 3E, respectively, did not result in significantly greater chemical sequestration or long-term effectiveness (see model output summarized in Table 3). By comparison, Alternative 2 – Enhanced Natural Recovery and Alternative 1 – Monitored Natural Recovery, had intermediate and low scores on this criterion, respectively.

Table 3
Summary of MTCA Remedial Alternative Evaluation

Alternative	Evaluation Criterion [1,2]								
	Compliance with Cleanup Standards; Protection of Human Health and the Environment	Reasonable Restoration Time Frame	Permanence	Maximum Future (500 Yr) Porewater PCB Conc. 10 cm Below Mudline (pg/L; see text)	Long-Term Effectiveness	Short-Term Risk Management	Implement-ability	Cost - Deposit 1 (see Table 4)	Cost - Deposit 2 (see Table 5)
Alternative 1 – Monitored Natural Recovery	+	-	-	100,000	-	+	+	$806,000	$471,000
Alternative 2 – Enhanced Natural Recovery (Thin Sand Cap)	+	+	o	10,000	o	+	o	$959,000	$352,000
Alternative 3A – Thick Sand Cap	+	+	o	2	+	+	o	$1,226,000	$215,000
Alternative 3B – Thin AquaBlok™ Cap	+	+	o/+ [4]	< 1	+	+	o	$1,643,000 [5]	-
Alternative 3C – Thick AquaBlok™ Cap	+	+	o/+ [4]	< 1	+	+	o	$2,626,000	-
Alternative 3D – Thin Coal and Sand Cap	+	+	+	< 1	+	+	o	$1,578,000 [5]	-
Alternative 3E – Thick Coal and Sand Cap	+	+	+	< 1	+	+	o	$2,408,000	-
Alternative 4 – Dredging, Off-Site Disposal, and Residuals Cap	+	o [3]	+	< 1	+	-/o [3]	-/o [3]	$5,061,000	$360,000 [4]

Legend:

- **-** The alternative satisfies the criterion to a low degree.
- **o** The alternative satisfies the criterion to a moderate degree.
- **+** The alternative satisfies the criterion to a high degree.

Notes:

1 - The threshold MTCA criteria, which must be satisfied for an alternative to be acceptable under MTCA, are not included in this table. All alternatives are judged to satisfy the threshold criteria.

2 - Consideration of public concerns is not addressed in this table since the public has not yet had an opportunity to provide comments.

3 - Short-term risk management and implementability characteristics are very site- and location-specific. Because of its relatively small size and off-channel location, Alternative 4 applied to Deposit 2 (Donkey Island side channel deposit) can be more readily implemented and effectively controlled (see text).

4 - Permanence of the AquaBlok™ remedy is dependent in part on the final TOC content of the cap material, which may vary depending on final design.

5 - The decision on whether Alternative 3B or 3D would be implemented in Deposit 1 would be based on which of these two options is less expensive, based on the outcome of more detailed final design and cost analyses.

Yellow highlighted cells summarize the recommended remedial alternative for the Upriver Dam PCB Site, as discussed in Section 6.3.

The long-term effectiveness of low-permeability sediment caps constructed with AquaBlok™ must also consider potential long-term instability of the cap due to potential buildup of decomposition gas from the sediments and organics under the cap. Post-cap evaluations have documented intermittent gas releases from AquaBlok™ caps that have been constructed without a gas venting layer, resulting in localized jointing of the cap surface, and reduced cap thickness near gas vents (Mutch et al. 2004). Preliminary evaluations suggest that the relatively narrow width of Deposit 1 (Figure 1) will likely allow for passive diffusion of methane and other gases laterally, reducing the potential for buildup of gas pressure beneath the cap. However, in order to ensure the long-term effectiveness of the cap, a 6- to 12-inch-thick gas diffusion layer (e.g., coarse sand) was integrated into conceptual design, placed below the AquaBlok™ layer, to vent gas laterally to the margins of the cap (Figure 4). Downward advective flow conditions occur at the Site (Patmont et al. 1985, Anchor and Hart Crowser 2003). Thus, the additional sand layer would improve physical isolation and upward diffusion potential (containment), while providing a safety component to mitigate potential gas effects on the cap. Detailed cap specifications, including evaluation of the need for a subsurface gas venting layer, would be developed during remedial design.

6.2.4 Management of Short-Term Risks

Management of short-term risks (a.k.a. short-term effectiveness) is the degree to which human health and the environment are protected during construction and implementation of the alternative. Potential risks of implementing each alternative and the potential effectiveness of best management practices at controlling short-term risks are discussed below.

Alternative 1 – Monitored Natural Recovery, does not present additional short-term risks to human health and the environment because there is no construction or implementation planned with this alternative. Alternatives 2 and 3A to 3E present minimal additional short-term risks to human health or the environment associated with implementation of the remedy, as the cap placement methods are not expected to result in water quality impacts beyond localized, minor turbidity increases. As discussed above, elutriate and sediment transport testing of alternative coal materials used in Alternatives 3D and 3E may be required to ensure that water quality and adjacent sediments are protected during and after construction. These alternatives thus would provide effective management of short-term risks resulting from implementation of the remedy.

Implementation of Alternative 4 – Dredging, Off-Site Disposal, and Residuals Cap, would result in potential releases of a range of contaminants (PCBs, metals, wood waste, and other associated chemicals) to surface water during excavation and/or dredging of sediments. Construction-related impacts to surface water quality and fluidized sediment residuals that may remain in and adjacent to the dredging area are highly site-specific. Short-term impacts associated with dredging PCB-contaminated sediments from Deposit 1 could be mitigated to varying degrees by using appropriate best management practices, though typical control measures such as silt curtains have often been proven to be relatively ineffective when applied in other similar riverine environments. The level of protection against short-term impacts for Deposit 1 is effectively correlated with cost and complexity. Thus, the greater the degree of protection required, the higher the cost will be. Relative to the other alternatives, Alternative 4 applied to Deposit 1 PCB sediments provides less effective management of short-term risks than other alternatives.

Depending on site-specific factors, dredging of certain locations within Upriver Dam may potentially be performed with relatively minimal short-term water quality and sediment residuals impacts. For example, because of its relatively small size and off-channel location, Alternative 4 applied to Deposit 2 (Donkey Island side channel deposit) can be more readily implemented and could be designed to provide effective short-term controls. As discussed in Section 5.4 above, the Deposit 2 excavation area under Alternative 4 was assumed to be isolated during construction from the Spokane River by placement of a small sand dam to control water quality and sediment residuals releases associated with excavation within this area. Thus, Alternative 4 applied to Deposit 2 PCB sediments can readily provide effective management of short-term risks.

6.2.5 Technical and Administrative Implementability

Evaluating an alternative's technical and administrative implementability includes consideration of the following:

- Potential for landowner cooperation
- Whether the alternative is technically possible
- Availability of necessary facilities, services, and materials
- Administrative and regulatory requirements
- Scheduling
- Size and complexity of the alternative
- Monitoring requirements
- Access for construction and monitoring
- Integration of existing operations with the remedial action

Alternative 1 – Monitored Natural Recovery, by definition, is the easiest to implement.

Alternatives 2 and 3A through 3E consist of demonstrated technologies that have been proven to be relatively easy to implement. However, federal CWA permits (likely Nationwide Permit 38) and accompanying Endangered Species Act consultation, along with pre-design engineering analyses and Ecology design approvals, would be required to implement this project. Although existing water uses in Upriver Dam would likely not be significantly affected by construction actions under these alternatives, coordination with river users would be required to implement this action.
Compared with the other alternatives, Alternatives 2 and 3A to 3E are moderately implementable.

Alternative 4 – Dredging, Off-Site Disposal, and Residuals Cap includes dredging PCB-, metal-, and wood waste-contaminated sediment. The potential for short-term impacts from dredging relatively highly contaminated materials will make meeting regulatory requirements more difficult. Current site uses and operations in the area would also be more significantly affected by this action. Thus, particularly within Deposit 1, this alternative has a lower implementability relative to the other alternatives evaluated. Because the Donkey Island side channel can be more effectively isolated during construction (see Figure 1), and also because of better access of land-based construction equipment to this deposit, Alternatives 3A and 4 are moderately implementable within Deposit 2, relative to the other alternatives.